MACHINE INNOVATION FOR INTER ROW COTTON CULTIVATION IN UZBEKISTAN

M. O. Amonov, A. S. Pulatov, T. S. Colvin

ABSTRACT. *Uzbekistan is a leading country in cotton production and export. Inter-row cultivation is an important production operation that assists in soil loosening, weeding, fertilizing, and ridge forming between rows. However, the operation is problematic because of risks of damaging the plants during critical growth phases. The article examines a new design for precision cultivator guidance for inter-row tillage and presents the results of field trials of the new design. The proposed cultivator utilizes light torsion pivots with gauging beams and guiding slits to allow a reduction of the protected zone surrounding the plant by 2 to 2.5 cm and improves the soil surface condition (soil crumbling ability). Herbicide use and hand labor can be significantly reduced, which should lead to an increase in profit. This cultivator also allowed for an increase in operating speed by 14%, which would increase the efficiency of the operation.*

Keywords. *Uzbekistan, Cotton, Cultivation, Mechanical cultivators, Protected zone, Herbicide, Guiding slits, Torsion pivots, Weed control, Cultivation accuracy, Loosening, Efficiency.*

Cotton has been grown in Uzbekistan for many years with production dramatically rising after the 1950's. Uzbekistan has maintained its' status as being one of the leading countries in cotton production (average cotton production 1.4 million tons/year) and cotton export (around 16% of cotton traded internationally) in spite of reduced acreage after 1991. Currently, cotton is cultivated on approximately 1.5 million ha, occupies almost 40% of the irrigated land, and provides about 50% of the hard currency income (UN Publication, 2001).

Cotton production practices include major operations such as preparing the soil, planting, inter row cultivation, watering, and harvesting. Inter row cultivation, is one of the major operations which promotes saving soil fertility, assists with weed control and the correct use of nutrient elements in the soil. All these attributes help the crops grow and develop. Cultivation starts very soon after planting, during germination of young crops, and continues 4 to 5 months until the end of the growing season. Inter row cultivation is one of the most problematic and costly operations for growers in Uzbekistan because it still requires using hand labor. Just for hand weeding growers spend up to 40% of the total cost for cotton production (Mirakhmedov, et.al, 1989).

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LITERATURE REVIEW

PROTECTED ZONE AND CURRENT REQUIREMENTS FOR INTER ROW COTTON CULTIVATION

Mechanical cultivators are major proven units for inter row cultivation in corn, cotton and soybean and have been successfully used in the United States, Canada and Europe. They can be effective for weed control when economical and environmental considerations are taken into account (Parish et al., 1995; Van Zuydam et al., 1995; Ben Yahia et al., 1999; Hanna et al., 2000; Thacker and Coates, 2002b). During inter row cultivation a unit, which consists of a tractor and cultivator, moves between the rows of the crop for soil loosening, weeding, fertilizing, and ridge forming. Unfortunately, these operations require very accurate driving to prevent plant damage leading to crop loss. The operating parts of the cultivator, depending on type and working depth, must maintain certain clearances from the crop line. Therefore, an uncultivated (protected) zone/strip centered on the plant row remains. The probability of cotton plant damage (mainly root damage and also damage from moving crops from the line in the first and second cultivations when plants are very small) is decreased when the protected zone is wide. However, a wide area of untilled soil is undesirable because weeds grow in this area and the soil crusts after normal spring rains which prevents the plants from developing. The soil crust is a natural phenomenon in the soil-climate conditions of Uzbekistan with crusting as a result of rains which provide up to 41% of the annual precipitation during planting and the beginning of cotton growing season (Sergienko, 1978).

It is beneficial to keep a proper width for the protected zone. Currently, various widths are established for specific operations. For instance, a protected zone width of 10 to 12 cm is established for the first cotton cultivation. Width of the protected zone is increased up to 15 to 20 cm in the second and third cultivations when the plants are larger. The following standards have been established in Uzbekistan as

Table 1. Performance standards for inter row cultivators within Uzbekistan.[a]

Protected zone widths, cm for:	
Rotary hoe	3–5
Spherical disks	8–10
Weed knives	10–15
Shovels	12–15
Openers (for fertilizers)	20–30
Tillage depths, cm for:	
Rotary hoe	3–5
Weed knives	6–8
Shovels	4–8
Sweeps	14–18
A standard deviation of tillage depth, cm	± 1
Soil loosening parts of a machine should produce percentages of soil particle sizes (soil crumbling ability), ±5%:	
100–50 mm	No more than 10
50–25 mm	No more than 20
25–0.25 mm	No less than 60
less than 0.25 mm	No more than 10
% of weeds that should be killed in the tillage area	98
Operating parts of a cultivator should not	Plug with weeds or accumulate soil
Plant damage allowed by tillage between rows	No more than 0.8%
Fruit elements allowed to be knocked off the plants during a trip through the field	No more than 0.2%

[a] Anon. Manual of basic requirements for tractors and agricultural machines, vol. 41, part 2, 1988.

requirements for mechanical cultivators used between cotton rows (table 1).

There are several possible ways of managing the protected zone. First, herbicides may be applied to this zone but there is concern about their impact on air, soil, and water and also the possibility of damage to the crop. A second alternative for weed control is hand weeding. Currently hand labor is still extensively used on cotton fields due to the lack of technical resources such as herbicides and cultivators with guidance systems which may help operators get close to the crop and reduce the need for hand weeding. It is of known importance that cultivation and weeding happen on time and this requires high efficiency machines for inter row cultivation. Medium density weeds in the field reduce cotton yields by 8% to 10% and high density of weeds increases this number 1.5 to 2 times (Fisyunov, 1984). If allowed to compete with cotton, some types of weeds might reduce yields up to 60% (Keeley and Thullen, 1989). With late cultivations, normal nutrition of cotton plants will be destroyed, primarily because of increasing weeds, which use moisture and the nutrient elements of the soil. Cotton yields can be reduced by 15-25% with late first cultivation (Mirakhmedov et al., 1989) and by 25% or more on delay of 4 to 6 days for next cultivations after watering (Kosov, et.al,, 1964). A total of 150-200 man-hours per ha may be used for hoeing and weeding cotton in Uzbekistan with medium and high density weeds in cotton fields (Sergienko, 1978). Third, reducing the working speed of tillage machines can increase accuracy and minimize the uncultivated area. However, this leads to a decrease in operational efficiency and the inefficient use of tractor engine capacity and an increase in fuel consumption. 30,000 tons of diesel fuel is wasted in cotton cultivation annually in Uzbekistan because of the inefficient use of tractors (Bakiev et al, 1988). Fourth, the application of special devices for better control of the operating parts of the cultivator, relative to the rows, allows improved accuracy of inter row tillage. These allow for the protected zone to remain narrow and 85% to 90% of the land to be tilled between rows (Beyseev, 1985).

Precision Guiding in Crop Row Cultivation and Cotton Cultivator

Precision guidance may help to provide more precise cultivation with mechanical cultivators used between the crop rows. As a result of rapid development in electronic and computer technology, automatic cultivator guidance systems have been developed. They use optical or ultrasonic guidance, radio navigation, or have sensing systems that are typically oriented toward the plants or toward guiding furrows (Reid et al., 2000; Han et al., 2004). In the system based on machine vision technology, a camera is used as a sensor (Wilson, 2000; Lamm et al., 2002). The global positioning system (GPS) is one of the common types of navigation sensors that can be used for guidance in cultivation (Larsen et al., 1994). These kinds of guidance systems are used very little in the fields of developing countries due to their complexity and high costs.

North America and Europe currently have simpler but still commercially available guidance systems which are utilized by a number of farmers. They keep the cultivator centered over the row and allow the cultivator to be adjusted closer to the crop without crop damage or root pruning. Very simple systems use guiding wheels with open furrows. More developed systems are automatic and in essence they are an interface between the implement and the tractor. They are of two types, side-shift (push), and articulated (pivot) and electro-hydraulic, which means that they have a sensing device which sends electric signals to actuate hydraulic rams and move the hitch or steer the tractor. All quick hitch systems work by sensing either a furrow, or the crop row. The furrows are created along the row line during planting or pre-plant tillage. Guiding furrows use either open furrows or slits hidden in the furrow floor (Research update by PAMI, 2000; Thacker and Coates, 2002a). However, the guidance system works well only with limited models of mainly rear attached (to tractor) cultivators. Usually the cultivator has to be attached to the tractor with a three-point hitch and using the system with wide and long implements or those having many or deeply penetrating tillage tools is a problem.

The use of open furrows has the disadvantage of being vulnerable to erosion by rain before any cultivation can be accomplished. Cultivators have been patented which use simpler gauges attached rigidly to the frame of the cultivator and follow guiding slits made during planting, which are hidden in the ground, but that may not be washed out by rain (Beyseev, 1985; Elsenard, 1978). In the United States a patent slit forming guiding device (Larsen, 1978) is available. This device is attached to a planter and forms two to four 10- to 13-cm deep slits depending on the number of rows and operating width of the machine. Gauges are attached to the front tire of the tractor to "lead" the tractor. Special teeth that clean the slits are attached behind the gauges. The Research Institute of Irrigated Vegetable Farming and Melon Cultivation in Russia developed a so-called "Astrakhan Technology" through research (Karlov, 1984). They developed guiding slit forming and gauging systems. This system used a means of hard attachment of gauges to the planter or cultivator frames. Slits are made during a pre-plant strip cultivation.

Automated equipment adjustments reduce operator fatigue, increase operational speeds, and require less operator skill. Unfortunately cotton planter and cultivator design peculiarities create a number of difficulties in introduction of these devices into agricultural practice and cultivation technology in Uzbekistan.

The mounted KXU-4 four-row cultivator is used today in cotton cultivation in Central Asia (manufactured by the joint stock company "Chirchikselmash" in Uzbekistan). This cultivator can work in inter row cultivation of cotton *(Gossypium hirsutum)*, corn *(Zea mays)*, and kenaf *(Hibiscus cannabinus)* with 60-, 70-, and 90-cm rows and has front and rear sections. The front section frames rigidly mount to the tractor side frames and there are two side and two optional front-wheel plough-beams. The rear frame of the cultivator also is rigidly mounted to the back of tractor and uses a central and two rear-wheel plough-beams. Figure 1 shows a schematic view of the rear central plough-beam with tillage tools (in the left) and a view of the plough-beam without tillage tools. Disks, weed knives, openers, and sweep are attached to the plough-beam with each plough-beam and gauge wheel on a parallel linkage and attached to the frame of the cultivator without horizontal pivots. The front plough-beam location allows constant and convenient vision for the operator but the speed and productivity of these units have a tendency to be lower because accuracy of moving the cultivator along the rows depends on defensive driving and the operator watching the working parts closely.

Figure 2 shows, as an example, the arrangement of operating tools for weeding and simultaneous fertilizer application in 90-cm rows. The cultivator might have from 29 to 42 tillage tools attached, depending on the type of operations (Anon.(Manual for users of KXU-4), 1985; Rukhsatov, 1993). The cultivator has long plough-beams; with the last tillage tool, located at the end of the rear plough-beams, more than 2 m from the tractor rear axle. As was mentioned earlier, these design features create difficulties in using automatic guidance systems and negatively affect the accuracy and speed of inter row cultivation. Using gauge wheels, parallel linkage attachments and springs to control tillage depth allow enough stability of movement during operation in the longitudinal vertical plane to give tillage tool depth stability. But, having stable movement in the horizontal plane is problematic. An operator corrects the cultivator position constantly during row cultivation by steering the tractor. This causes stresses in the KXU-4 attachment links, plough-beams, and cultivating implements. This causes breakdowns, steering problems, and plant damage. In addition, research shows that the widths of the protection zones are not maintained. This leads to root damage and considerable crop loss. One cultivation can cause from 2% to 3% loss of yields (Senkin, 1983). Using an

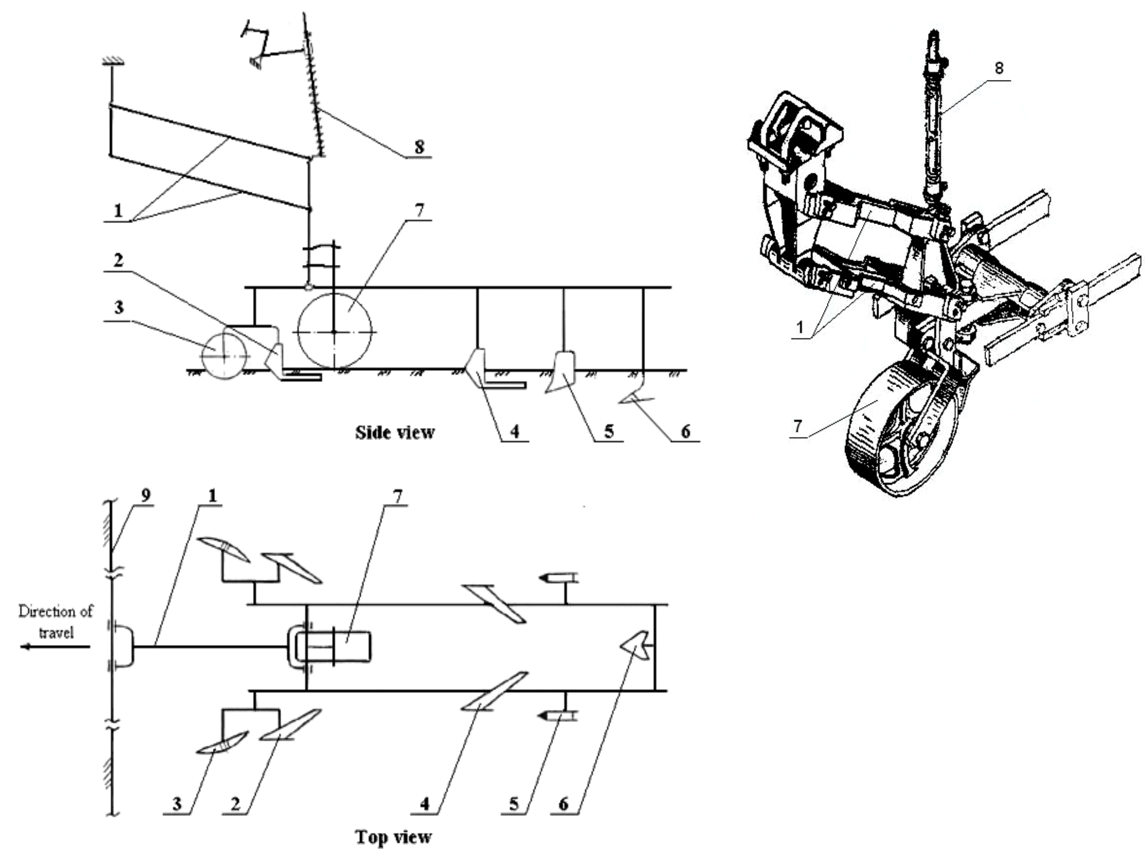


Figure 1. The rear plough-beam of major cultivator KXU-4 as used in Uzbekistan (schematic picture of the rear central plough-beam with tillage tools on the left). 1- parallel linkage; 2,4 – weed knives; 3 – disk; 5 – opener (for fertilizer); 6 – sweep; 7 – gauge wheel; 8 – spring for the control tillage depth; 9 – cultivator frame.

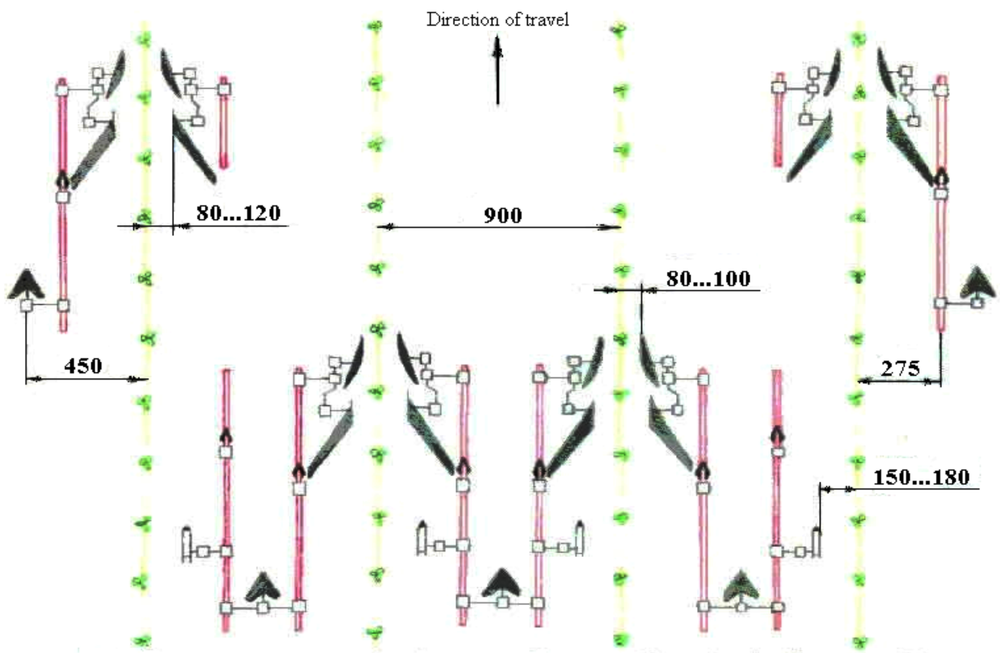


Figure 2. Arrangement scheme of operating tools for weeding and fertilizer application into 90-cm cotton rows (numbers in mm).

additional guiding device in the cultivator without changing the design will intensify these problems.

Study Objective

The overall objective of this study was to develop a pivoted cotton cultivator with gauging beams which use guiding slits between rows. The specific objectives were to determine the effects of cotton cultivation by pivoted cultivator with three versions of gauging beam attachment and its comparison with the commonly used major cultivator KXU-4. Factors affecting the cultivator's performance included cultivation accuracy measured by the size of protected zones and soil loosening quality as measured by soil crumbling ability. It was also planned to check the possibility of increasing operation speed and calculate the economic benefits from using the new design.

Materials and Methods

Proposed Pivoted Cultivator

We propose a cotton cultivator with pivots for use with gauging plough-beams and guiding slits. The gauging beams are attached to the frame with a parallelogram four-link mechanism, pivot, and spring torsion control (fig. 3). Every beam has a disk-stabilizer and a guiding device. The guide slit maker is installed on the planter and is used for making a guiding track for the cultivator. During cultivation, the disk-stabilizer will move along the slit made in advance and at the same time will renew the slit for the next operation. This makes for stabilized beam section movement between the rows.

With the proposed pivoted cultivator doing the inter row cultivation, it is not easy for the tractor to go out of the row center because of the guiding slits but if it happens, the operator steers the tractor to correct the tractor and cultivator position. This stresses attachment links, plough-beams and cultivating implements but not as badly as when no pivot was used because there is no need for lateral movement of the tools. In this case, the pivot with torsion spring twisting and each beam with tillage tools move along with the tractor (fig. 4). The spring torsion also helps keep the beams in a stable position when moving the cultivator from one field to the next or when turning the tractor at the end of the field.

Design and development of the proposed cultivator with pivoted gauge beams was done at the Tashkent Institute of

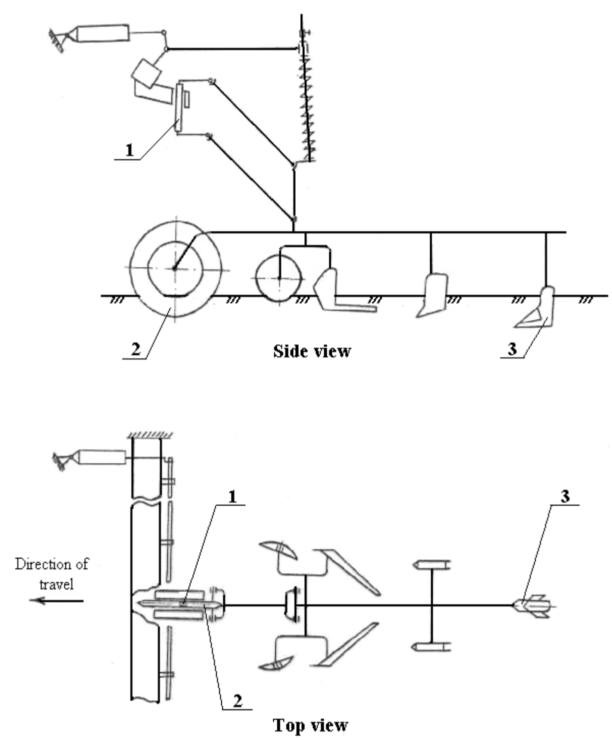


Figure 3. The new pivoting beam of cultivator (schematic picture). 1 – pivot; 2 – disk-stabilizer; 3 – guiding device.

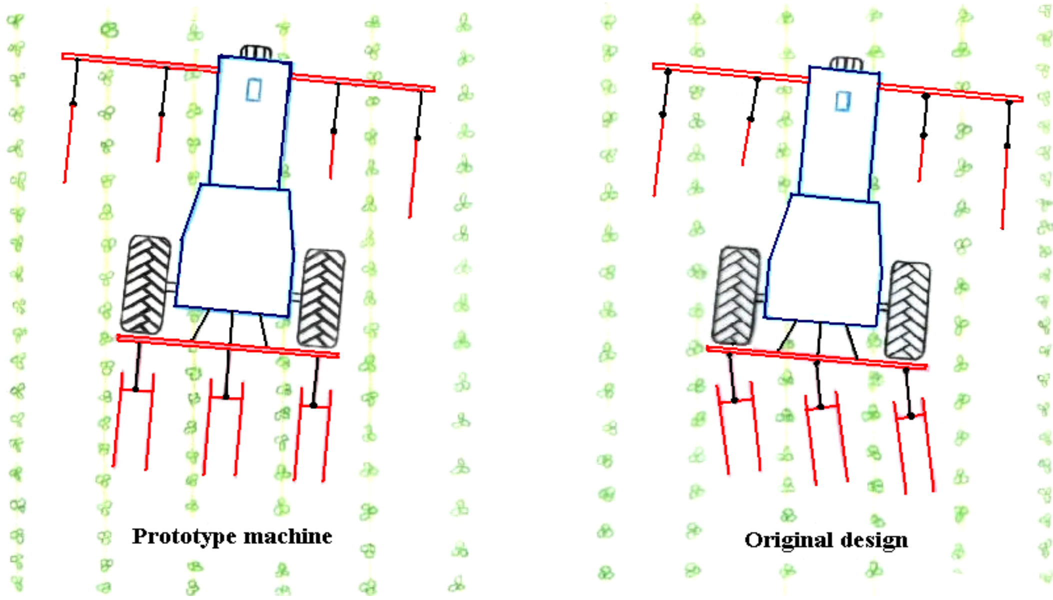


Figure 4. Tracking of row unit during operation.

Irrigation and Agricultural Mechanization Engineers (TIIAME) [Recently the Agricultural Mechanization College of TIIAME where the pivoted cultivator was developed was moved to Tashkent State Agrarian University (TSAU). The name of TIIAME was also changed to Tashkent Institute of Irrigation and Melioration (TIIM) to reflect moving the Agricultural Mechanization College to TSAU.]. The experimental unit which was made for experimental testing and attached to the tractor is shown in figure 5.

Experimental Site

The pivoted experimental cultivator was tested in the Sirdarya region of Uzbekistan during May and June 1988. The experimental site was in a cotton field and the cultivator was equipped with disks, weed knives, openers and sweeps for the first cultivation. The disks cultivated both sides of the protected zone. Table 2 provides the data about the site conditions.

Figure 5. Experimental pivoted cultivator attached to the tractor Belarus MTZ-80X.

Experimental Design

Currently in Uzbekistan, farmers are using different tractors from western countries for plowing the soil and for land preparation operations. Some widely used tractor series are Magnum and Maxxum made by CNH (Case New Holland Company, Lake Forrest, Ill.). But in planting and inter-row cultivation of cotton, the primary tractor is still the three-wheel tractors (MTZ-80X) made in Byelorussia by the

Table 2. The conditions of experimental site.

Date	14 May – 24 May 1988
Location	State farm #10, Sirdarya region, Uzbekistan
Type of operation	First cultivation
Type of soil	Typical serozem (clay loam soil)
Relief	Flat
Micro relief	Feebly marked
Soil moisture, % in the depth:	
0–5 cm	7.32
5–10 cm	10.66
10–15 cm	17.54
Soil hardness, mPa in the depth:	
0–5 cm	0.97
5–10 cm	2.78
10–15 cm	3.07
Previous soil operation	Planting
Planting type	Close cluster sowing
Crop	Cotton
Stage of growth	2–3 leaf
Width of crop rows, cm	90
Mean square deviation of rows, cm	2.66
No. of weeds on 1 m^2	4
No. of rocks with diameter more than 25 mm on 1 m^2	None

Figure 6. First cotton cultivation during the experiments.

Minsk tractor plant and the TTZ-80X made in Uzbekistan by the Tashkent tractor plant. During the experiments, the pivoted cultivator was mounted on a three-wheel Belarus 80-hp MTZ-80X tractor (figs. 5 and 6). Tests were run according to State standard 70.4.3-82. Three different travel speeds 0.48-0.51, 0.63-0.67, and 1.25-1.47 m/s (1.73-1.84, 2.27-2.41, and 4.50-5.29 km/h) were tested with three versions of gauging beam attachment to the frame of cultivator. They are:

- free pivoting (no spring),
- light torsion spring pivoting, and
- heavy torsion spring pivoting.

As was mentioned earlier, the commonly used KXU-4 cultivator has a beam attachment without a pivot and during the experiments it was used as a study base line. Thirty-six, 4-row plots (3.6 m wide × 40 m long) were used for conducting the experiments. Each individual plot was split into two parts; tractor speed was stabilized during the first 15 m and measurements were conducted on the remaining 25 m. During the experiments, cultivation accuracy was measured by the size of protected zones and soil loosening quality as measured by soil crumbling ability. After cultivation, the track of disks relative to the axis of travel was defined and the size of the protected zone was determined. Fifty measurements were made on the 25 m length of plot cultivation, one measurement every 0.5 m. In order to determine the soil crumbling ability, soil samples were collected from the plot after cultivation. The samples were taken on a 0.25-m^2 area to the cultivation depth. The samples were divided into fractions, the size range of which was: more than 100, 100-50, 50-25, 25-10, 10-0.25, and less than 0.25 mm and weighted. Standard soil sieves were used. Each treatment was replicated three times.

Study Results

Cultivation Accuracy

Accuracy has been determined by the standard deviation of the protected zone. Therefore, a more accurate operation should display a lower standard deviation. Table 3 shows the results of cultivation accuracy by different beams during the first cotton cultivation.

The free pivoting cultivator had a slight advantage in comparison to the commonly used KXU-4 cultivator if the operating speed was 0.5 to 1.1 m/s, but at higher speeds it is harder for an operator to react to the necessary position changes and the cultivation accuracy is not much better than the commonly used cultivator.

Table 3, in general, indicates better accuracy with the light torsion spring pivoting cultivator as compared to free pivoting or heavy torsion springs. Entire freedom of beam movement in the horizontal plane (pivoting attachment without spring) does not provide the anticipated cultivation accuracy because the beam is very sensitive to any accidental deviations or auto fluctuations of the operating parts during the row cultivation. If freedom of beam movement is not enough (attachment with heavy spring pivoting) the same negative impact occurs, but at a smaller scale, just like with an attachment without a pivot (for example, the commonly used KXU-4 cultivator). Figure 7 shows comparative graphs of the pivoted cultivator with light torsion spring beams and the commonly used KXU-4 cultivator in accuracy.

A few things are noteworthy about the beam location impact in regard to maintaining cultivation accuracy. It is known that the location of side beams in comparison to the central beam is not as good because they are further from the central axis and from the tractor's back wheel axle. The central beam is the best location. The experimental data showed this during cultivation with the commonly used cultivator when the operation speed was low (fig. 7a). But when a light torsion spring pivoting attachment was used the

Table 3. Cultivation accuracy during the first cotton cultivation.

Various Beam Pivoting to Cultivator Frame	Travel speed (m/s)	Left Side Front Beam			Right Rear Wheel Track Beam			Center Rear Beam		
		Avg. Size of Protected Zone (cm)	Standard Deviation (cm)	Coefficient of Variation (%)	Avg. Size of Protected Zone (cm)	Standard Deviation (cm)	Coefficient of Variation (%)	Avg. Size of Protected Zone (cm)	Standard Deviation (cm)	Coefficient of Variation (%)
Free pivoting (without spring)	0.51	8.42	1.430	17.0	6.82	1.410	20.7	7.44	1.564	21.0
	0.67	8.64	1.091	12.6	8.78	1.390	15.8	5.92	1.129	19.1
	1.47	8.98	1.225	13.6	5.60	1.414	25.3	5.50	1.044	19.0
Light torsion spring pivoting	0.49	7.28	0.981	13.5	7.68	1.224	15.9	8.48	1.081	12.7
	0.63	8.12	0.863	10.6	9.60	0.959	10.0	6.16	0.987	16.0
	1.25	8.94	1.066	11.9	5.74	0.795	13.9	7.34	0.992	13.5
Heavy torsion spring pivoting	0.50	9.74	1.527	15.7	8.12	1.380	17.0	9.38	1.907	20.3
	0.66	9.48	1.253	13.2	6.88	1.107	16.1	7.88	1.211	15.4
	1.47	6.08	1.093	18.0	6.88	1.275	18.5	6.50	1.005	15.5
Commonly used KXU−4 cultivator	0.50	10.18	2.847	28.0	6.76	2.635	39.0	6.88	1.935	28.1
	0.65	7.16	1.736	24.2	8.92	2.018	22.6	7.18	1.367	19.0
	1.39	8.32	1.287	15.5	10.98	1.304	11.9	7.28	1.331	18.3

differences in cultivation accuracy between the different beams was not pronounced (fig. 7b). First of all, using disk-stabilizers and guiding slits on each beam helped to reduce standard deviations of the protected zone. To have better accuracy, it also helps to have a pivot on each beam attachment. For the soil conditions at the experimental site, which was typical for the region, the light spring pivot worked better than the other mounting types. In general, the light torsion spring pivoting allows the protected zone to be reduced by 2 to 2.5 cm while increasing the cultivation speed by 14%. Reducing the protected zone allows a decreased herbicide application rate. A smaller protected zone also decreases the need for hand labor, which decreases production costs. Increasing the speed of cultivation will increase the efficiency of the operation.

Soil Loosening Quality

Usually after cultivation comes another operation, such as ridge forming and furrow watering. The sizes of the clods of dirt (aggregates) left by the cultivator are also important for success of these operations. Disk stabilizers on the pivoted cultivator will move along the central parts of the rows breaking up large clods of dirt. Samples were taken from the field after cultivation to determine the soil crumbling ability. Table 4 represents the ratio of the soil fractions that were determined after cotton row cultivation using the commonly used KXU-4 cultivator and the pivoted gauging beam cultivation. The study showed that the use of the pivoted gauging beam cultivator for the cotton row cultivation, improves the soil crumbling ability. It shows a noticeable reduction of the soil fraction, which is bigger than 100 mm (fig. 8a).

There is a 10% to 15% increase in the valuable soil particles that are less than 10 mm after using the pivoted gauging beam cultivator (fig. 8b). The torsion springs on each beam create a vibration while operating. These vibrations seem to improve the soil crumbling ability.

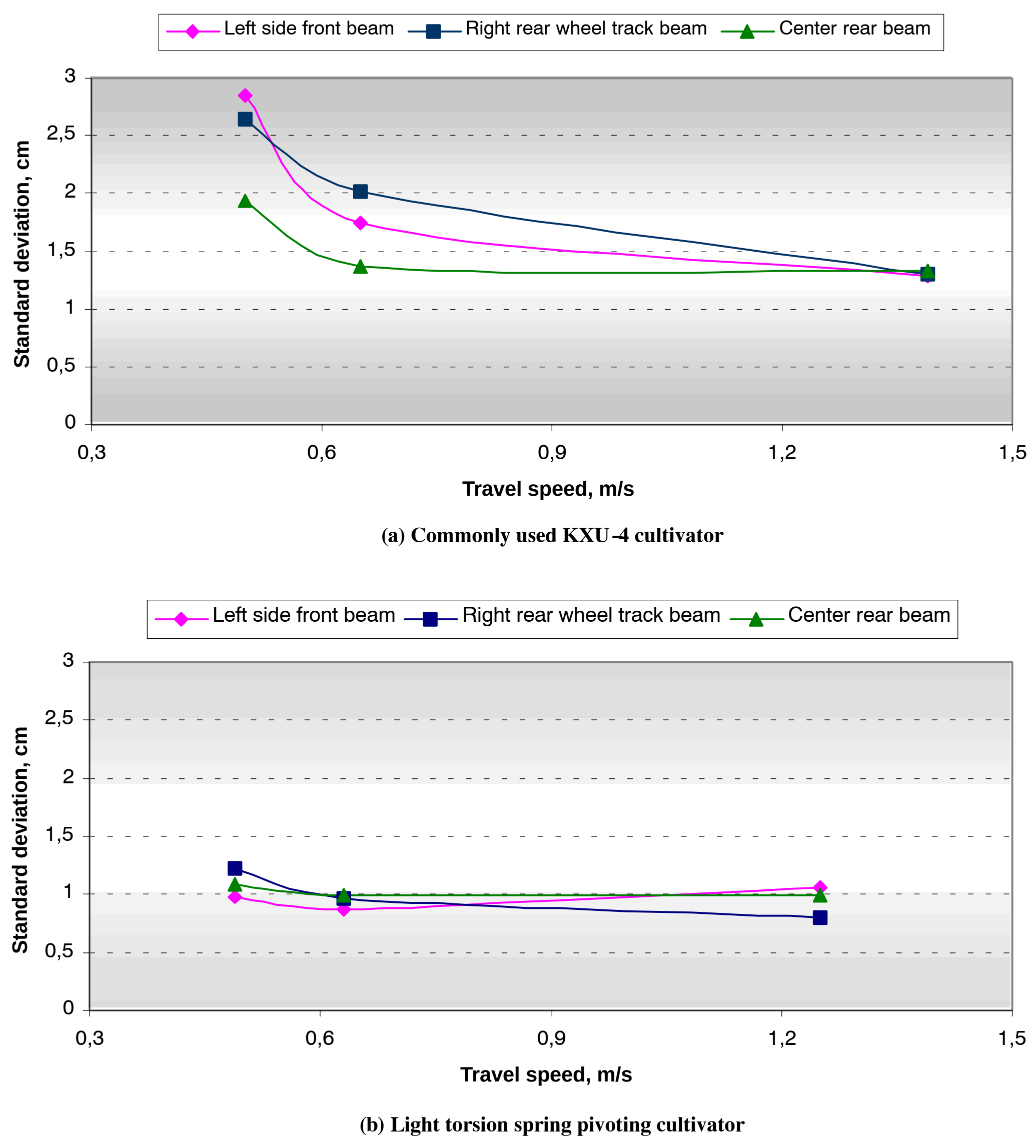


Figure 7. Accuracy of cultivation.

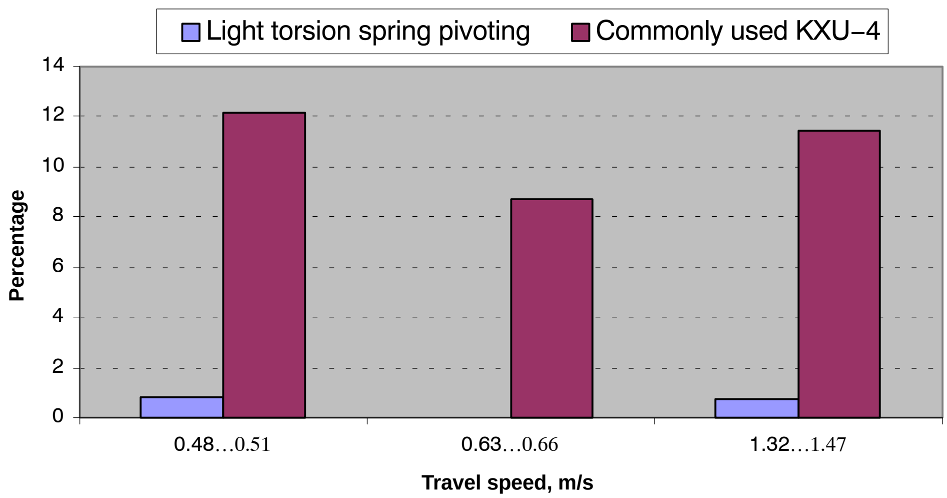
Table 4. Soil fractions after cultivation.

Various Beam Pivoting to Cultivator Frame	Travel Speed (m/s)	Percent of Particle Distribution by Size (mm)					
		> 100	100–50	50–25	25–10	10–0.25	< 0.25
Free pivoting (without spring)	0.48–0.51	4.80	4.32	7.66	14.01	59.87	9.34
	0.63–0.66	3.47	5.52	8.18	13.88	59.64	9.31
	1.32–1.47	1.78	4.28	6.54	13.45	63.97	9.98
Light torsion spring pivoting	0.48–0.51	0.85	6.23	8.11	14.40	60.90	9.51
	0.63–0.66	0	6.59	8.13	15.10	60.71	9.47
	1.32–1.47	0.79	5.20	7.15	13.88	63.13	9.85
Heavy torsion spring pivoting	0.48–0.51	4.10	5.64	8.19	14.10	58.79	9.18
	0.63–0.66	4.29	4.46	6.64	13.83	61.22	9.56
	1.32–1.47	2.36	4.70	6.38	13.54	63.16	9.86
Commonly used KXU–4 cultivator	0.48–0.51	12.15	6.45	10.37	16.04	47.57	7.42
	0.63–0.66	8.73	7.39	12.04	16.45	47.91	7.48
	1.32–1.47	11.48	10.89	9.05	16.28	45.24	7.06

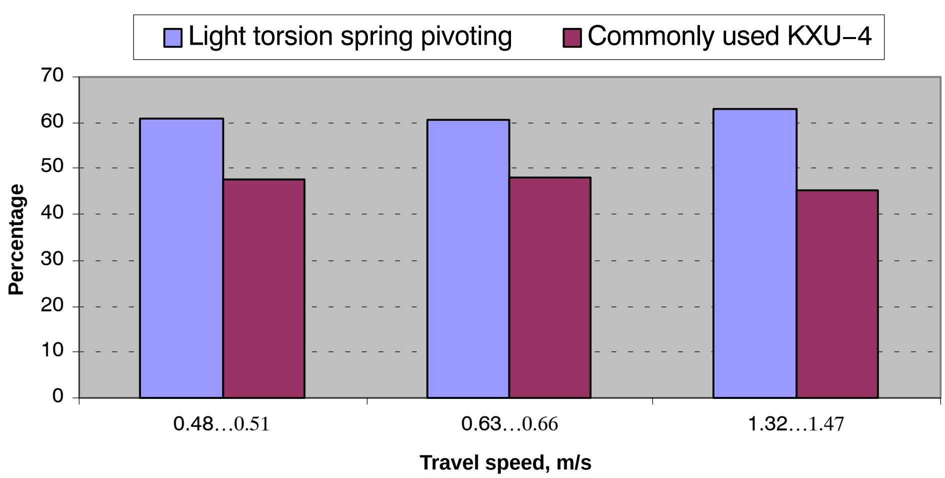
Economic Benefits

The economic benefits of using the pivoted cultivator with gauging beams can be seen in the following ways:

- higher efficiency of the operation because of high operation speed as compared to the commonly used cultivator;
- higher yield of cotton because of higher accuracy and less losses during cultivation; and
- less need for hand labor weeding because of cultivation with a narrower protected zone.



(a) Larger than 100 mm



(b) Between 10-0.25 mm

Figure 8. Percentage of particles in cultivation with different cultivators.

Calculations are given of hand labor savings due to reduced weeding resulting from the increase in mechanization using the pivoted cultivator with gauging beams added. As was mentioned earlier, the pivoted cultivator allowed cultivation with a narrow protected zone. For calculation, we used a width of protected zone in cultivation with the commonly used cultivator of 12 cm and for cultivation with the pivoted cultivator of 9.5 cm. The extent of mechanization may be calculated using the following formula:

$$M = (B - 2m) \times 100 / B, \% \qquad (1)$$

In this equation B is the width of cotton rows; and m is the width of protected zone. If the values of the protected zone cited above for 90-cm rows are used, the extent of mechanization using the commonly used cultivator is 73.3%, whereas with the pivoted cultivator this percentage increases to 78.9%. The increase in the extent of mechanization can now be calculated as:

$$K = (78.9 - 73.3) / 78.9 = 0.071 \qquad (2)$$

This means cotton cultivation with the pivoted cultivator cuts the cost of hand weeding by 7.1%. A 7.1% reduction in hand labor means a saving of between 11 and 14 man hours per ha in fields with medium and high density weeds in Uzbekistan.

Summary

The study indicates that using hidden slits in cotton cultivation gave better accuracy with the pivoted gauge beam cultivator as compared to the commonly used KXU-4 cultivator. It is desirable to use light torsion spring pivoting for the gauge beam cultivators. This spring allows the protected zone to be reduced by 2 to 2.5 cm while increasing operating speed by 14%. Reducing the protected zone should allow a decrease in the use of herbicide, which reduces damage to the environment. The smaller protection strip also allows for about 7% less hand labor, which cuts operating costs. Increasing the operating speed increases the efficiency of the operation. The experimental study also showed that the soil crumbling ability of the soil was improved by cultivation using the developed pivoted cultivator with gauging beams.

Postscript

The pivoted cultivator design described is protected by author certificate USSR #1565365 (1988). After tests in 1988, the pivoted cultivator was modified and in 1990 was successfully tested on the Central Asian Machine Test Station located in Uzbekistan. As the result of later tests, the cultivator design was modified one more time and in 1992 the “Chirchikselmash” plant manufactured 150 pivoted cultivators. Some of them are still being used today in Uzbekistan for cotton cultivation. All modifications of the cultivator subsequent to the original study were of a minor nature with the central concept of using spring pivots, guiding slits and guiding elements retained. The study findings reported in this paper were in part previously presented at the ASAE 1997 Mid-Central Meeting in St. Joseph, Missouri (paper no. MC97-111).

The described research study started at the end of Soviet time and continued during the first years of independence of the Republic of Uzbekistan. For several years the agriculture in Uzbekistan was under transition and has suffered from low levels of agricultural productivity and economic efficiency. Rapid privatization of farms offers hope of improvements in efficiency and productivity as individual responsibility and incentives for achieving efficiency increase. Today Uzbekistan’s private farmers remain highly interested in cutting costs of cotton production and are looking for machinery that works more efficiently and yields a better harvest. They are not so interested in buying old style agricultural machinery (for example the “Chirchikselmash” plant in 1990 produced 7500 KXU-4 cultivators but in 2002 produced only 780 units). The decentralization and privatization of Uzbekistan’s agriculture sector is an important force encouraging innovation and reform of Uzbekistan’s agricultural practices carried forward from the Soviet era.

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